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Transmission of lithic and ceramic technical know-how in the Early Neolithic of central-western Europe: Shedding Light on the Social Mechanisms underlying Cultural Transition

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Abstract:

Research on the European Neolithisation agrees that a process of colonisation throughout the sixth millennium BC underlies the spread of agricultural ways of life on the continent. From central to central-western Europe, this colonisation path is characterised by one single cultural entity, the so-called Linear Pottery Culture (LBK). At the transition between the sixth and fifth millennia BC, the LBK breaks apart into a mosaic of “post-LBK” cultural groups through mechanisms that are not entirely understood. To contribute to a better understanding of the social processes underlying this transition, here we conduct an integrated analysis of the lithic and ceramic technical subsystems attributed to the LBK and post-LBK in Middle Belgium, a region with unrivalled material evidence. We use the technical gestures carried out by the early farmers to produce their lithic tool blanks and ceramics as proxies to shed light on (i) the modalities of technical know-how intergenerational transmission, (ii) the possible exogenous influences within the technical system, (iii) the trajectories of the social groups involved in the LBK-Blicquy/Villeneuve-Saint-Germain (BQY/VSG) transition. Our results reveal that several overlapping mechanisms were at work during this cultural transition. While lithic and ceramic general technical trends are clearly transmitted from one period to another attesting to a clear filiation between the LBK and post-LBK, both the lithic and ceramic detailed sequences of technical gestures tend to hybridize after the transition. This reveals close and prolonged interactions between groups of producers from different learning networks, most likely stemming from population mobility during the cultural transition.

Key words: European Neolithisation, lithic industry, ceramic production, learning networks, cultural transition, migrations, socio-economic behaviours

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Databases are freely available in Supplementary Materials: <https://osf.io/bgzhn/>

Code availability

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Ethics approval (include appropriate approvals or waivers)

There are no ethical issues regarding the achievement of this research.

1. Introduction

It is generally accepted that the Neolithic transition in continental Europe during the sixth millennium BC occurred through a rapid process of colonisation from Transdanubia (Hungary) to Normandy, characterised archaeologically by the so-called Linear Pottery Culture (or *Linearbandkeramik*, abbreviated LBK). Studies on the LBK have led to a homogenous perception of this cultural entity, on the basis of its architecture, funerary practices and material culture (Bickle & Whittle, 2013; Lichardus & Lichardus-Itten, 1985). LBK communities were organised in villages undergoing regular cycles of scission after reaching certain demographic thresholds (Dubouloz, 2012). However, at the turn of the sixth millennium BC, the LBK broke apart into a mosaic of cultural groups all over Europe. Major trends regarding this shift are characterised by the adoption of new architectural standards, new ceramic styles and a redefinition of raw material circulation networks (e.g., Gleser & Hofmann, 2019). During the second half of the fifth millennium, various elements across the European territory point to a demographic boom, an increase in social complexity and segmentation, with the emergence of agglomerations and mining complexes, underlying social hierarchies and inequalities (e.g., Bostyn, 2018; Collin, 2019; Hofmann & Gleser, 2019; Kerig et al., 2015). Ultimately, the beginning of the fifth millennium characterised by the post-LBK groups, appears as an "in-between" in the midst of the Early Neolithic and the Middle Neolithic (Demoule, 2010). "Transition is defined first of all as an in-between which enables us to assess continuities and discontinuities, to pass from one period to another" (Müller, 2016, p. 12). This paper aims to better understand the social mechanisms underlying the period of transition defined by the post-LBK. To do this, it is crucial to focus on the processes at play at the end of the LBK which are yet not entirely understood, notably because of their diversity at the European scale. For instance, a continuity in site occupation has been demonstrated between the LBK and the post-LBK in Saxony and Bohemia (e.g., Link, 2015; Stäuble, 2014; Zápotocká, 2007). On the contrary, a chronological gap is documented between the end of the LBK and the beginning of the post-LBK in the Upper Rhine region (e.g., Denaire et al., 2017), where some LBK mass graves such as Herxheim or Talheim have been discovered (e.g., Meyer et al., 2014; Zeeb-Lanz, 2009). On the Aldenhoven Platte (North Rhine-Westphalia), a massive demographic decline has been highlighted (Balkowski, 2017; Zimmermann, 2009), whereas in the Paris Basin a population increase during the Blicquy/Villeneuve-Saint-Germain seems to occur (Bedault, 2009; Dubouloz, 2008).

This variability of historical scenarios leads us to believe that working at the micro-regional level is a prerequisite for a more comprehensive understanding of this transitional phenomenon at the European level. The scale of the settlement area in fact allows us to deal with two concepts, that of "inheritance" and that of "generation", which have been highlighted as two heuristic concepts to grasp mechanisms of historical transition (Müller, 2016, p. 16). In this article, these concepts have been mobilised through an integrated analysis of the lithic and ceramic technical subsystems attributed to the LBK and post-

LBK in Hesbaye (Middle Belgium) (fig. 1). This region, with a post-LBK period characterised by the Blicquy/Villeneuve-Saint-Germain culture (BQY/VSG), includes numerous settlement sites attributed to the Early Neolithic. However, with a record of 350 LBK sites and only two BQY/VSG ones (Jadin, 2003), the transition here seems to be characterised by a form of rupture linked with an important decrease in population, in line with the archaeological record in the Aachen area (Zimmermann, 2009).

The neolithisation of Middle Belgium has been the subject of intense debate since the 1980s, largely sparked by the chronological and cultural connection between the LBK and the post-LBK. Three models have been proposed: (i) anteriority of the BQY/VSG in regard to the final stage of the LBK in the Paris Basin (RFBP) (Jeunesse, 2001); (ii) contemporaneity between both entities (Cahen & Gilot, 1983); (iii) succession, with a possible overlapping, of the LBK and the BQY/VSG (Constantin, 1985; Dubouloz, 2003). The *Mission Archéologique du ministère des Affaires étrangères français en Hainaut et en Moyenne Belgique* has contributed to these debates, in particular through the research conducted in the Verlaine and Vaux-et-Borset sites in Hesbaye (Constantin & Burnez-Lanotte, 2008) and provided evidence in favour of the third model (Constantin et al., 2010).

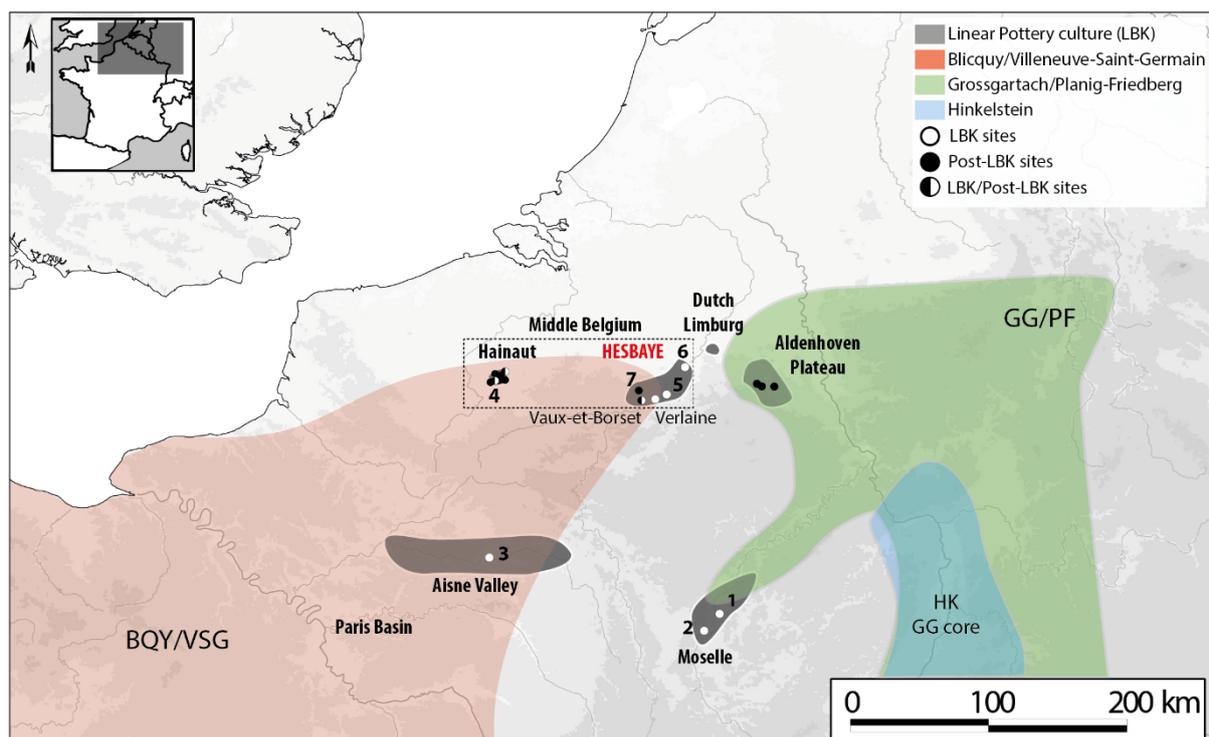


Fig. 1 General map of the archaeological context under study: Middle Belgium and surroundings areas mentioned in the text. Verlaine and Vaux-et-Borset sites (Hesbaye) are the key sites of the study. 1: Ennery; 2: Metz "Nord"; 3: Cuiry-lès-Chaudardes; 4: Aubechies; 5: Fehxe-le-Haut-Clocher; 6: Rosmeer and 7: Darion

A general consensus regarding the chronological succession between the LBK and the BQY/VSG is now established (Constantin et al., 2010; Jadin, 2007). Our studies have thus focused on the socio-

cultural dynamics defining the relation between these two entities. Three scenarios have been so far proposed to explain the transition between the LBK culture and the post-LBK groups:

(i) *an endogenous process linked to profound socio-cultural mutations in LBK populations*. Several authors have suggested that the transition between the LBK culture and post-LBK groups stemmed from socio-economic transformations in LBK communities, and that these gave then rise to a reconstruction of regional cultural identities (Constantin, 2013; Constantin & Ilett, 1998; Constantin et al., 2010);

(ii) *a syncretic process, relating to the integration of Neolithic populations from contemporaneous cultural entities, or traits thereof*. This hypothesis is essentially based on the idea of a Mediterranean influx into western LBK communities: diffusion of limestone bracelets, southern influences in pottery decoration styles, specific bone tools (Constantin & Vachard, 2004; Hauzeur & Van Berg, 2005; Lichardus-Itten, 1986; Sidéra, 2008)

(iii) *a syncretic process, relating to the final stage of integration of hunter-gatherer populations into Danubian Neolithic populations*. This premise is essentially founded on the presence of two specific types of ceramic ware in an LBK context, one known as La Hoguette, the other as Limburg, whose origin is still the matter of an intense debate (e.g., Jeunesse, 2002; Manen & Mazurié de Keroualin, 2003).

These scenarios, which are not necessarily mutually exclusive, thus confront two processes: an endogenous or internal one, in which LBK and BQY/VSG would be part of a single Danubian tradition, and an exogenous or external one, in which the emergence of BQY/VSG would result from intercultural interactions. To unravel these scenarios and grasp the continuous or discontinuous nature of the connection between the LBK and the post-LBK cultures in middle Belgium, here we reconstruct the technical gestures and know-how implemented for the production of both lithic tool blanks and ceramic ware at the Early Neolithic villages of Verlaine (LBK) and Vaux-et-Borset (both LBK and BQY/VSG) (fig. 1). Through the synchronic and diachronic evaluation of lithic and ceramic technical traditions, this article aims to trace the social groups involved in the LBK-BQY/VSG transition and to identify possible exogenous influences within the technical system, in the context of an apparent rupture between the two entities.

2. Material and method

2.1. Vaux-et-Borset and Verlaine: two key sites for the beginning of the Neolithic in Belgium

The line of thought presented here is based on the technological study of the lithic and ceramic assemblages discovered at the Early Neolithic sites of Verlaine and Vaux-et-Borset, both of which are located in the east of Belgium (in the geophysical region of Hesbaye). These sites are among the best documented for the period (Burnez-Lanotte et al., 1993, 2001; Constantin & Burnez-Lanotte, 2008) in this densely populated region during the early Neolithic (e.g., Jadin, 2003). They also both have been

the subject of detailed technological analyses of lithic and ceramic assemblages (Allard, 2005a, 2005b, 2007; Allard & Burnez-Lanotte, 2006; Burnez-Lanotte & Allard, 2003; Caspar & Burnez-Lanotte, 1994, 1997, 1998, 2003; Denis, 2017; Denis & Burnez-Lanotte, 2020; Gomart, 2014; van Doosselaere et al., 2013, 2016), enabling to conduct an unprecedented crossover study of the evolving dynamics of the technical systems. Verlaine and Vaux-et-Borset were both occupied during the LBK, while Vaux-et-Borset only yielded a BQY/VSG occupation.

The 'Le Petit Paradis' site in the Verlaine municipality of the Hesbaye region is located on a plateau of loess, 300 m east of the Yerne river. It has been explored over a surface of 15,600 m², although the total occupation area is estimated at 3 or 4 ha (fig. 2). The pit containing thousands of pieces of flint knapping waste and hundreds of blade cores, initially discovered by E. Vanderhoeft, is in fact part of a classic village. This village is made up of 140 structures, in addition to between six and fourteen buildings, depending on the scenario, organised in parallel lines in an NNE/SSE orientation (Burnez-Lanotte, 2010). Twenty-one smaller flint debitage clusters have been uncovered in addition to the initial discovery. Although the southern, eastern and western limits of the village have been identified, the occupation seems to extend further to the north (Allard & Burnez-Lanotte, 2008). The Verlaine occupation lies in a region rich in Early Neolithic sites. At least twenty LBK sites are known in a 3 km radius. The chalk substratum in the Campanian levels of the Nouvelles assises contains abundant flint. Apart from Verlaine, debitage clusters were found in five other occupations, including the famous Dommartin site, which, according to the literature, comprises at least 19 clusters (Allard, 2005a, pp. 124–125). The seriation of the ceramic decorations from Verlaine is still in progress. Nevertheless, a first periodisation of different motifs and decorative themes in nine of the pits (structures 1, 2, 56, 10, 23, 29, 34, 61 and 62) places site occupation in the IIc and the beginning of the IIId phases, according to the Dutch Limburg chronological sequence, that is, the recent stage of the LBK (Modderman, 1970). These nine structures seem to form a chronologically homogenous ensemble (Allard & Burnez-Lanotte, 2008).

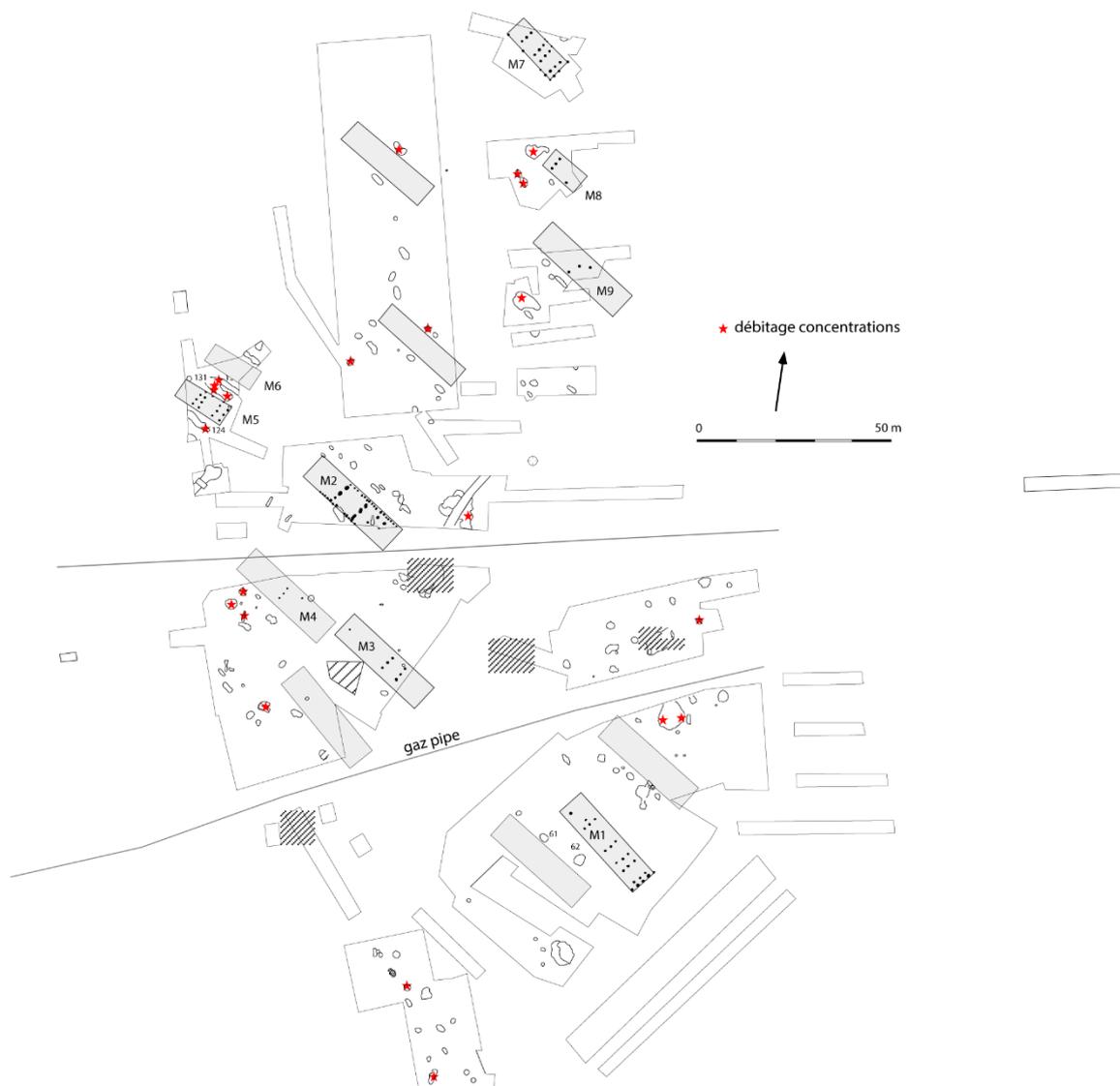


Fig. 2 Verlaine site map with representation of the determined housing units and the debitage concentrations. According to Burnez-Lanotte, 2010, DTP/CAD: P. Allard

The excavation sections ‘Gibour’ and ‘À La Croix Marie-Jeanne’ (Villers-le-Bouillet) at the Vaux-et-Borset site revealed two adjoining villages, dating from the earliest Neolithic in Hesbaye: one belonging to the Linear Pottery Culture, the other to the post-LBK. The two settlements are spatially exclusive of one another (fig. 3), and a minimum distance of 40 m separates the closest structures from each occupation. The presence of the LBK is demonstrated by structures belonging to two building categories: an enclosure and a village. The enclosing system is solely demarcated by a ditch with an irregular oval layout, with an estimated perimeter of 810 m, and marks the boundaries of an area of 4.5 ha. Most of the LBK settlement is inside the enclosure. It consists of at least five houses and their construction trenches, as well as an ensemble of 16 intersecting silos, and 35 pits predominantly spread out inside the enclosed area. In the current state of research (seriation of the ceramic assemblages in

progress), the settlement is attributed to the second half of the late LBK for the Meuse basin (i.e. LBK B of Blouet et al., 2013; Modderman Iib, Iic of Modderman, 1970) and to the final LBK (Modderman IId). The adjoining post-LBK occupation extends over two sectors, of which almost 13,000 m² have been explored: one on the ridge and on the upper part of the southern side of the ‘Gibour’ site (some ten metres west of the LBK settlement), the other some hundred metres west of the ‘À la Croix Marie-Jeanne’ site. Due to intense erosion of the ridge in particular, no habitation plan could be unearthed. Nevertheless, the characteristics of some structures suggesting lateral pit complexes, as well as refits, indicate the possible presence of at least five buildings (Burnez-Lanotte et al., 1993, 2005).



Fig. 3 Vaux-et-Borset site map with representation of the determined housing units. North-Western part corresponds to the Blicquy/Villeneuve-Saint-Germain village; the South-Eastern part refers to the enclosed LBK village. According to Denis & Burnez-Lanotte, 2020 modified DTP/CAD: C. Swijsen and S. Denis

2.2. Methods

2.2.1. General objectives of the method

Based on the premise that every technical gesture is a social fact (Cresswell, 2003), our ambition here is to decipher the transition mechanisms between the LBK and BQY/VSG, focusing on the transmission of the technical know-how carried out for the production of two crucial elements of the first farmers’ economy: flint blanks for lithic tools and pottery. Such cross-cutting analyses are often difficult to carry out because the available documentation is incomplete and the study of the various artefacts tend to be methodologically separated from each other (Beugnier & Maigrot, 2005). However, the analysis of the different technological subsystems that make up a technical system provides a more nuanced picture of the first farmers’ techno-economic dynamics and is ultimately the only way to understand the

phenomena of social reproduction and change in all their complexity. “Technical behaviours are transmitted by observation and are reinforced and stabilised by effective repetition. In this way, the acquisition conditions lend a certain inertia to technical skills, through the respect of common standards and habits. This justifies the term ‘technical tradition,’ which is ‘the sum of shared and transmitted choices’ [...]” (Pelegrin, 1985, p. 83). These traditions are identified through the technological analysis of production, based on the methodological concept of *chaîne opératoire* (Leroi-Gourhan, 1964), in which technical actions are divided into distinct steps, which are sometimes subdivided into sequences and operations (Balfet, 1991), or technical processes (Inizan et al., 1995; Pelegrin, 1995). This division provides for a strategic and rigorous understanding of the technical gesture along two lines of interpretation: method and technique. As defined by Jacques Tixier (Tixier, 1967), method describes the design (order and combination) of the different actions between themselves, while technique describes the mode of action in contact with the physical matter. Thus, the characterisation of methods and techniques highlights the “strategic operations” (Lemonnier, 1976, 1980) that structure the *chaînes opératoires*. In contrast, certain gestures may prove to have no technical basis, either for the completion of the manufacturing process or for the functional character of the produced object. Consequently, these actions or technical processes carry a strong identity signature. By identity, we are referring to the affiliation of producers to a given social group, the nature of which may vary. In actualist contexts, social groups may for instance correspond to gender groups, families, castes, sub-castes, factions, classes, lineages, clans, ethnic groups, tribes, ethno-linguistic groups...(Roux, 2011). Defining these *chaînes opératoires* and their variability, in the absence of functional constraints, leads to the identification of “ways of doing” (e.g., Roux, 2010), for which the multiplication of detailed observations enables us to set aside possible technical convergences when carrying out comparisons on a large scale (Gosselain, 2018), and thus to identify the social groups in charge of production. Defining these *chaînes opératoires* diachronically then makes it possible to assess continuity or discontinuity in the transmission of technical know-how between generations. When temporal or spatial continuity in technical practices is identified, i.e. transmission of technical know-how from generation to generation among a community of practice, “ways of doing” can be defined as “technical traditions”.

Changes within the technical system generally point to a redefinition of social identities within a given context, whether these changes take place within the confines of a single community, or result from interactions between different communities (Roux, 2019). As sequences of technical gestures reflect deeply anchored facets of producers’ identities, evidence for discontinuity or, on the contrary, continuity, is always very consequential with regard to socio-cultural dynamics. Indeed, diachronic continuity in technical traditions shows the local permanence of producers’ social group over time through an intergenerational transmission of knowledge (Roux, 2020). Discontinuity raises the question of the nature and origin of the new way of doing to determine whether the changes observed in technical practices are related to endogenous or exogenous factors. The analysis of discontinuity provides crucial information about mobility patterns and relationships between different social groups (Roux, 2011).

Through the detailed reconstruction of the technical gestures and the tools associated with the manufacture of flint blades and pottery, our objective is thus to explore these dynamics and trace the spatial trajectories of the early farming communities in central-western Europe, extending the discussion beyond the geographical region of Hesbaye (fig. 1). While the raw materials used for flint tools have been taken into account in the present article, the study on pottery has been focused on forming gestures, which represent extremely stable know-how within a given apprenticeship network as several ethnohistorical studies (e.g., Mayor, 2011; Roux, 2019) and archaeological research (e.g., Vandiver, 1987; Roux & Thalmann, 2016) show. Once sequences of technical gestures have been embodied during the learning process, producers tend not to question or change them, passing them down through generations (e.g., Gosselain, 2002). In contrast, raw materials, which provide extremely valuable information for understanding the organisation of pottery production or to assess circulation networks of goods, tend to change much more within a given community of practice depending on various factors, such as consumer demand, local standards (e.g., Gelbert, 2003), or changes in the producers' environment in the context of migrations (e.g. Gabriele et al., 2022).

2.2.2. The lithic industry

In the scope of this study, the analysis of lithic techniques focuses on blade production. Acquiring the skills necessary for the production of blades entails long and sustained training (Pelegriin, 1991, 2007), in order to obtain a certain technical consistency. In the absence of systematic refitting, apart from the Verlaine cluster, the blades themselves, representing the materialisation of the aims of production, form the basis of our study.

Early Neolithic LBK and BQY/VSG sites are very much alike in terms of the technical setting for the production of tool blanks (e.g., Allard & Bostyn, 2006). The *chaîne opératoire* for blade production is well documented by studies carried out by us at an earlier date (Allard, 2005a; Allard & Denis, 2022; Denis, 2017) and the description of the diacritical sketches of the studied blades. To shape the block, one or two crests need to be created. Shaping begins with hard percussion, then crests are generally formed through indirect percussion (punch technique). This technique is also used for blade debitage, and carried out according to a unipolar pattern. Intervening from the base serves to correct accidents or to maintain convexities, as well as to create neo-crests. Debitage is rotating or semi-rotating. The objective of production is for the most part a small blade of about ten centimetres in length, with a trapezoidal cross-section of 18-20 mm width, and a thickness of 4-6 mm (fig. 4, a).

The morphological or qualitative constraints imposed by the raw material have to be evaluated before a possible technical response can be identified. For our survey area, the clastic properties of the materials used are globally comparable. It is the origin of the materials, however, that greatly helps to determine

the peregrinations of the technical groups in question. As there is no reference collection for the raw materials found in Hesbaye, they are traditionally considered to consist of fine and coarse flints (Allard, 2005a). The first derive from the Campanian, the latter from local Maastrichtian levels. Although few outcrops have been recorded to date, we consider these flints to be of local to regional origin, as we cannot systematically determine the distance to the extracted deposits (0-30 km). Potential deposits of Campanian and Maastrichtian flint outcrop in secondary positions near the Vaux-et-Borset site (Caspar & Burnez-Lanotte, 1994). They are chiefly used for the production of flakes, and their morpho-dimensional characteristics could render them inadequate for blade production, which would suggest a more distant origin for the blocks selected for blade making. The Verlaine outcrops are local (Allard, 2005). Given the absence of a regional rock reference collection, the origin of certain raw materials, and Maastrichtian flint in particular, remains open to question. The variability of the latter in the assemblages could suggest diversified origins that cannot be evaluated for the time being. Two other raw materials are mentioned in this study: Ghlin flint and tertiary Bartonian flint. Ghlin flint comes from the Mons Basin (Hainaut). The deposits have not yet been precisely located, but the most recent indications point to a probable origin near Baudour (Collin, 2016, 2019; Leblois, 2000), ca. 100 km from Vaux-et-Borset. Bartonian flint originates from the Paris Basin, 250 km to the southeast (Allard et al., 2005; Blanchet et al., 1989).

Defining technical traditions also involves evaluating the knappers' level of know-how. To determine knappers' shared norms and practices, the objectives or intentions of production have to be perfectly established. The faulty pieces left by apprentice knappers can represent technical variability, created by the imperfect execution of the technical gesture.

Finally, non-essential processes and technical gestures bearing strong identifiability are confined to the platforms and the preparation of blade detachment. They attest to the variability of technical gestures and tools that differentiate distinct groups of producers (Denis & Burnez-Lanotte, 2020). In the absence of exhaustive refits, notably at Vaux-et-Borset, the proximal parts of blades are the best vector for characterising these technical lithic traditions (fig. 4, b).

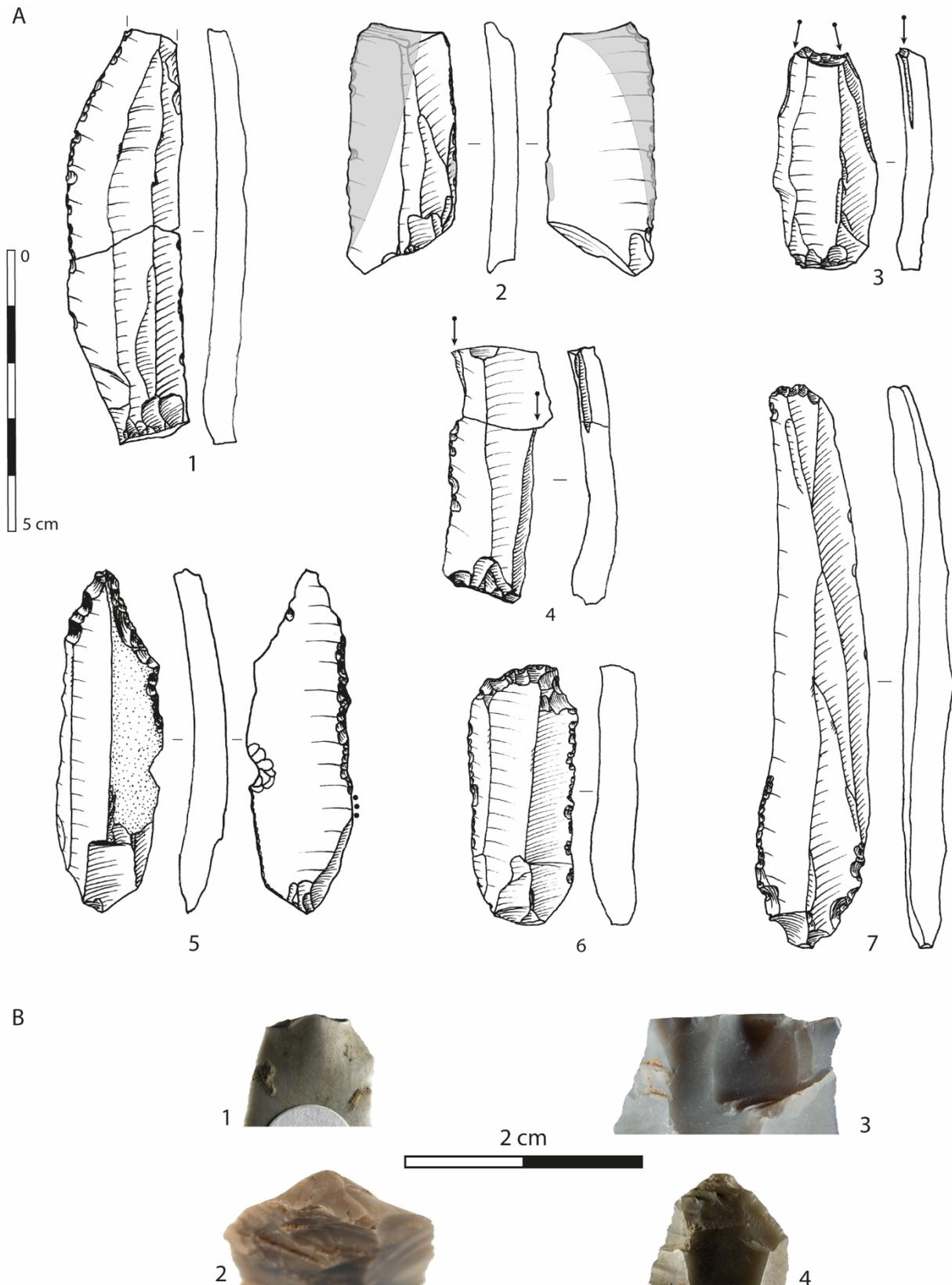


Fig. 4 Vaux-et-Borset blades. a, drawings showing the characteristics of intended laminar blanks in the danubian Early Neolithic of North-Western Europe, drawings: S. Denis. Campanian flint (1 to 3), Bartonian flint (4 and 6), Ghlin flint (5 and 7). Retouched blade (1), sickle (2), burins (3 and 4), borer (5), scrapers (6 and 7). b, pictures of discrete characters visible through proximal blade parts analysis, photos: ©Unamur/Save-dva. Campanian flint (2 and 3), Ghlin flint (1), other (4). Morphological

dihedral butt (1) versus flat butt (2), the first is linked to preparation of striking platform by small flakes versus no preparation. Overhangs very well prepared with a stone (4) or backed overhang prepared with punch (3). Important difference of butt dimensions: wide (3) and thick (2), narrow (4) and thin (1 and 4)

2.2.3. Pottery forming

The spatial organisation of pores and mineral inclusions, as well as surface topography, are subject to the type of pressure applied to clay during shaping. As a result, the systematic examination of these characteristics on archaeological ceramics yields coherent and reproducible indications on the technical gestures carried out during the manufacture process (Pierret et al., 1996). Several ethnographic and experimental works based on such premises demonstrate a direct link between certain technical gestures (e.g., rolling, beating, pinching) and specific configurations left on outer and inner pottery surfaces (e.g., Livingstone Smith, 2001). The macroscopic examination of ceramics concentrates on (1) the organisation of pores and mineral inclusions, as well as correlating discontinuities in the radial and equatorial sections; (2) topographical surface characteristics; (3) variations in the thickness and texture of the walls, and (4) fractures and fissures networks. The interpretations of these technical traces and methods of shaping are based on several archaeological, experimental and ethnographical works of reference (e.g., Gelbert, 2003; Livingstone Smith, 2001; Rye, 1981; Shepard, 1976).

2.3. Lithic and ceramic material under study

2.3.2. Lithic sample

Our study is based on the detailed examination of a sample consisting of 398 pieces from Verlainne (tab. 1), corresponding to the proximal parts of a selection of blades found inside five different pits (124, 130, 131, 61 and 62). The studied objects were found in both domestic waste and debitage concentrations. The whole set of blades from Vaux-et-Borset, 1,941 pieces, was also studied (Denis & Burnez-Lanotte, 2020). They come from the LBK area (755 artefacts) and the BQY/VSG section (1,186 artefacts) of the site (tab. 2).

Verlainne Features	debitage concentration			domestic waste			total
	Campanian	Maastrichtian	undeter.	Campanian	Maastrichtian	undeter.	
124	26	-	-	8	-	1	35
130	39	-	-	22	-	-	61
131	79	-	-	150	1	2	232
130-131	12	-	-	17	-	-	29
61	-	-	-	2	20	-	22
62	-	-	-	3	14	2	19
total	156	0	0	202	35	5	398

Table 1 Number of lithic artefacts studied in Verlainne according to their context of discovery and their raw material. The databases related to the studied material are available in Supplementary data

Houses/structures	Ghlin	Tertiary Paris Basin	Campanian Hesb.	Maastrichtian Hesb.	other	indetermined	total
LBK_H1	-	-	37	1	2	2	42
LBK_H2	-	-	97	2	8	4	111
LBK_H3	1	-	36	5	0	4	46
LBK_H4	-	-	35	36	3	3	77
enclosure	-	-	5	-	-	2	7
other structures	2	0	416	31	6	17	472
total LBK	3	0	626	75	19	32	755
BQY/VSG_H1	150	29	114	18	10	26	347
BQY/VSG_H2	43	13	50	9	7	4	126
BQY/VSG_H3	46	25	216	42	20	29	378
BQY/VSG_H4	39	9	27	2	7	3	87
BQY/VSG_H5	56	8	43	3	4	9	123
other structures	42	11	43	14	6	9	125
total BQY/VSG	376	95	493	88	54	80	1186

Table 2 Number of lithic artefacts studied in Vaux-et-Borset according to their context of discovery and their raw material. The databases related to the studied material are available in Supplementary data

2.3.2. Ceramic sample

This ceramic sample comprises 652 vases from Verlaine (tab. 3). Here, the results obtained at Verlaine are put into perspective by comparing them to those from seven other LBK sites (Gomart, 2014). For reasons of accessibility to materials, the ceramic assemblage from the LBK village of Vaux-et-Borset had to be excluded from this first integrated analysis. We could however use the results of the thorough technological analysis carried out by B. van Doosselaere on 268 BQY/VSG vessels from the Vaux-et-Borset site (van Doosselaere et al., 2013, 2016).

Verlaine LBK Features	fine ware	coarse ware	Total
1	3	9	12
14	-	2	2
15	1	4	5
22	1	-	1
23	8	6	14
25	6	1	7
26	3	1	4
34	1	17	18
51	-	2	2
56	1	4	5
60	3	10	13
61	14	23	37
62	24	44	68
66	4	12	16
67	10	5	15
68	1	-	1
69	1	1	2
71	1	-	1
74	6	-	6
78	1	2	3
81	11	-	11
84	1	-	1
87	4	3	7
90	11	5	16
94	2	15	17
95	4	8	12
100	-	1	1
105	-	1	1
124	15	14	29
128	18	6	24
129	8	16	24
130	22	12	34
131	69	131	200
150	1	13	14
156	1	-	1
162	11	-	11
others	7	10	17
Total	274	378	652

Table 3 Number of pottery vessels studied in Verlaine according to their context of discovery and their main characteristic. The databases related to the studied material are available in Supplementary data

3. Results

3.1. The LBK lithic and ceramic technical subsystems

3.1.1. The LBK lithic industry from the Verlaine and Vaux-et-Borset sites

Recent studies, on which the present paper is based, describes the most pertinent technical criteria for distinguishing the different ways of doing in Early Neolithic blade production in Hesbaye (Denis & Burnez-Lanotte, 2020; Denis et al., 2021).

During the LBK, one way of doing clearly dominates the assemblages of Vaux-et-Borset and Verlaine (MF1) (fig. 5). It is similar on both sites and has been identified on two of the extracted materials, i.e., Campanian and Maastrichtian flint, although the latter was clearly less prevalent. The first material is, incidentally, exclusively found in the Verlaine debitage concentrations (Allard, 2005). Tables 4 and 5

compare the descriptive criteria of this way of doing at Verlaine and Vaux-et-Borset. On the latter site, we excluded the pieces on which we could not determine the percussion technique employed in the preparation of the overhang. The descriptive criteria were, in point of fact, not completely compatible with all of the MF1 (Denis & Burnez-Lanotte, 2020). As compatibility is decidedly more pronounced in Verlaine, the pieces from that site were included in the description of that way of doing. These technical characteristics are extremely similar between the two LBK sites. Blade overhangs are preferentially prepared with small punch strokes. The butts are quite massive, and smooth and flat butts clearly dominate the assemblages, especially at Verlaine. They attest to the absence of specific striking platform preparation. Four-faceted blades are a little more prevalent at Vaux-et-Borset than at Verlaine. But it is the blades with a trapezoidal section that seem to have been the intended result at both sites (about 60% of the blanks). The operative code conveys the order in which removals were detached. On the blades with a trapezoidal section, the quantity of 123/321 and 212' codes is similar. The non-prevalence of 212' codes suggests that knappers did not look for, did not know of, or did not master, the specific organisation that results in the repeated fashioning of blades with a regular trapezoidal section (with regard to strategies cf. Pelegrin in Astruc et al., 2007; Binder, 1991; Binder & Gassin, 1988). The most obvious difference between the two sites concerns the larger quantity of regular and very regular blades at Verlaine, which suggests a better level of technical know-how. This superior level of know-how has already been brought to the fore (Allard, 2012) and is explained by the particular character of the site, with its surplus production of blades (Allard, 2007). The nature of techniques on the Verlaine site is remarkably homogeneous, particularly between domestic waste and debitage concentrations, as already underlined by P. Allard and L. Burnez-Lanotte (Allard, 2005b; Burnez-Lanotte & Allard 2013). This homogeneity is shared with the site of Vaux-et-Borset.

		Verlaine_LBK_MF 1									
Raw material		Campanian et Maastrichtian									
Total number of pieces and %		357 pieces, around 90% of total									
overhang preparation		punch		no preparation				unspecified tool			
number and %		204	57	91	26	62	17				
butt surface (mm2)		44,7									
butt types		flat		concave		morphol. dihedral		"true" dihedral		other	
number and %		300	84	26	7	13	4			19	5
sections	2 facets (number and %)	43				22					
	3 facets (number and %)	124				62					
	4 facets (number and %)	32				16					
	<i>total</i>	199				100					
operating codes	123 (number and %)	51				46					
	212' (number and %)	59				54					
	<i>total</i>	110				100					
regularity	very regular' and 'regular' (number and %)	261				74					
	not very regular' and 'irregular' (number and %)	91				26					
	<i>total</i>	352				100					

Table 4 Description and quantification of all the characteristics of the lithic most dominant way of doing (MF1) (*beta* technical tradition) identified on the blades of Verlaine. The regularity is evaluated on representative fragments following 4 levels (0. very regular; 1. regular; 2. not very regular; 3. irregular) according to the parallelism of the edges and arrises and the uniformity of the ventral face

		Vaux-et-Borset_LBK_MF 1									
Raw material		Campanian, Maastrichtian									
Total number of pieces and %		269 pieces, 78 % of proximal parts									
overhang preparation		punch					no preparation				
number and %		176	65				93	35			
butt surface (mm2)		44,16									
butt types		flat		concave		morpho. di.		true dihedron		others	
number and %		209	78	10	4	17	6	3	1	30	11
sections	2 facets (number and %)	37					22				
	3 facets (number and %)	99					59				
	4 facets (number and %)	31					19				
	<i>total</i>	167					100				
operating codes	123 (number and %)	55					48				
	212' (number and %)	60					52				
	<i>total</i>	115					100				
regularity	very regular' and 'regular' (number and %)	168					62				
	not very regular' and 'irregular' (number and %)	101					38				
	<i>total</i>	269					100				

Table 5 Description and quantification of all the characteristics of the lithic most dominant way of doing (MF1) (*beta* technical tradition) identified on the LBK blades of Vaux-et-Borset. The regularity is evaluated on representative fragments following 4 levels (0. very regular; 1. regular; 2. not very regular; 3. irregular) according to the parallelism of the edges and arrises and the uniformity of the ventral face

Yet, in the same way as what was observed at Vaux-et-Borset (Denis & Burnez-Lanotte, op. cit, MF4), the overhang of some pieces at Verlaine could have been subject to preparation with another type of tool, such as a stone hammer rather than a punch. The analysis of half of the 16 identified pieces at Verlaine is more uncertain. The paucity of the Verlaine corpus is not conducive to statistically reliable descriptions and comparisons. Just like at Vaux-et-Borset, the butts of these blades - which were prepared for detachment with a stone tool - are smaller than those observed on the MF1 blades. Still, they are slightly larger at Verlaine (38.5 mm²) than they are at Vaux-et-Borset (21.9 mm²). The nature of the butts reflects the preparation methods applied to the striking platforms, and is comparable to those of MF1, although the blades could be a little less regular, keeping in mind the quantitative limitations imposed by this ensemble. These few blades from Verlaine will be labelled MF6 while awaiting a discussion on their status.

The examined LBK collections are thus dominated to a large extent by one way of doing (MF1), identified at both Verlaine (n=357) and Vaux-et-Borset (n=269). Some very rare pieces could tend to stand out in that a stone tool was used in preparation for detachment. We have labelled them MF4 (n=32) at Vaux-et-Borset and MF6 (n=16) at Verlaine (fig. 5). The predominance of MF1 on both sites suggests its wide transmission, which enables us to interpret this way of doing as a technical tradition (that we term Tradition *beta*). The distribution area of this technical tradition could be much wider. Indeed, in view of the present data, it could also be identified on local materials (Deramaix, 1990, flint drawings A) in the Hainaut Province in Belgium (Allard, 2005a, fig. 133; Denis et al., submitted). It is however difficult to quantify in this context, as it seems to coexist with another way of doing, characteristic of

the Paris Basin (Allard, 2005a; Allard & Denis, 2022). The most easterly LBK sites of the Aldenhoven Plateau and Dutch Limburg could also represent an industry with a comparable way of doing (Allard, 2005a; de Grooth, 1987; Zimmermann, 1995). Some faceted striking platforms are mentioned in the Dutch Limburg area (de Grooth, 2007). A finer technological analysis of these assemblages is however needed to understand if they result from specific maintenance or if they occur because of a possible coexistence of several ways of doing.

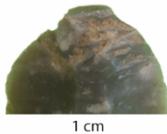
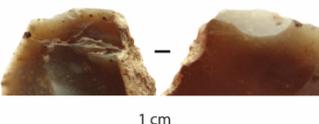
Ways of doing things	Main Technical Criteria	LBK	BQY/VSG	Illustration
Alpha tradition=MF2	striking platforms prepared by small flakes; butts morphologically dihedral or flat, often concave; punch laid in the concavity; preparation of overhangs with a stone tool; good knowledge of the specific arrangements for obtaining blades with regular trapezoidal cross-section		Vaux-et-Borset	
Bêta tradition=MF1	flat striking platforms, without specific preparation; flat butts, wide and thick; preparation of overhangs with a punch; blades with a more irregular tendency; no knowledge of the specific arrangements	Verlaine and Vaux-et-Borset	Vaux-et-Borset (and Darion)	
MF3	striking platforms prepared by small flakes in order to obtain a dihedron; dihedral butts; punch laid on the dihedron; tool to prepare overhangs needs to be better define; very good knowledge of the specific arrangements for blades with regular trapezoidal cross-section; unidirectional		Vaux-et-Borset	
MF4	flat striking platforms, without specific preparation; flat butts of medium dimensions; preparation of overhangs with a stone hammer; no knowledge of the specific arrangements	Vaux-et-Borset		
MF5	mostly flat striking platforms but frequently flakes are removed; flat butts of small dimensions; preparation of overhangs with a stone tool; good knowledge of the specific arrangements for blades with regular trapezoidal cross-section		Vaux-et-Borset	
MF6	flat striking platforms, without specific preparation; flat butts, wide and thick; preparation of overhangs with a stone hammer; no knowledge of the specific arrangements	Verlaine		

Fig. 5 Synthesis of the lithic ways of doing and technical traditions highlighted in Verlaine and Vaux-et-Borset

3.1.2. The LBK ceramic production from the Verlaine site

A total of 652 vases from the ceramic assemblage of Verlaine were examined, and the manufacturing *chaîne opératoires* was identified for 315 of them (Gomart, 2014). Four ways of doing were differentiated, one of which is clearly predominant (VPP1), while three others are less prevalent (VPP 2, 3 and 4) (fig. 6).

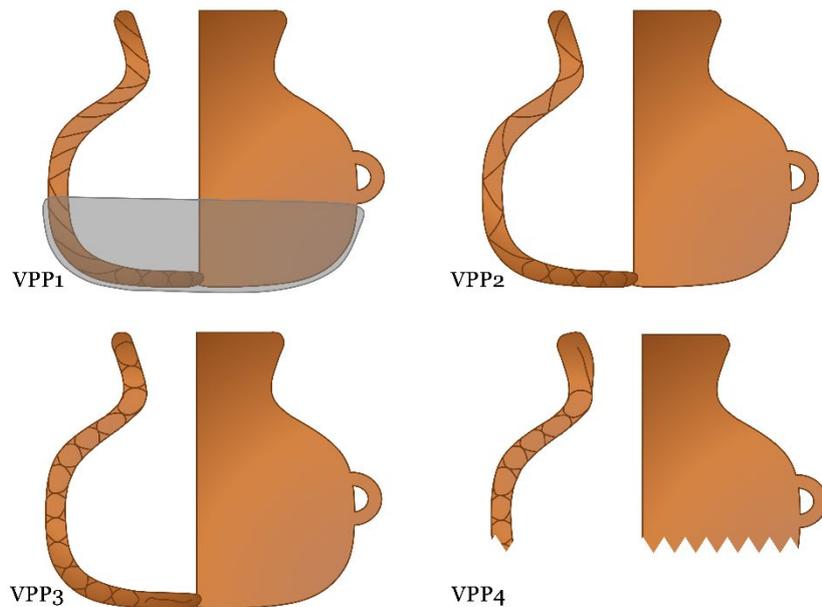


Fig. 6 Schematic representation of the four ceramic ways of doing identified in Verlaine

The first (VPP1, n=281) is characterised by roughing-out the vessels' base by means of the spiralled coil technique, and the shaping that followed by stretching out the rough-out against a support. In the radial section, the body, neck and rim show regularly spaced oblique voids, with variable orientation depending on the tilt of the wall. When the wall opens out, the orientation of the voids is internal. If, on the contrary, the wall closes in, orientation is external. This configuration indicates a roughing-out of the body, the neck and the rim through the use of elongated coils, where the direction of overlapping depends on the orientation of the walls. This way of doing is attested, always in low proportions, at other LBK sites (named Tradition 3 at the scale of the western LBK in Gomart, 2014): in the Hesbaye Region, Rosmeer (early/middle LBK) and Fehxe-le-Haut-Clocher (late and final LBK), in Hainaut at Aubechies (late and final LBK) and in the Aisne valley, in Cuiry-lès-Chaudardes (late and final LBK).

The second way of doing (VPP2, n=10) includes vessels with a base shaped using a spiralled coil. The body, neck and rim are shaped from coils, with an alternating internal and external orientation (Z or S configuration). In between those voids, inclusions and pores show a vertical orientation. This type of

configuration could either attest to a roughing-out of the body, neck and rim through the superimposition of thin coils (followed by stretching during shaping), or a roughing-out through alternating interior and exterior compression of the coils. This way of doing has been identified in important proportions at other LBK sites (named Tradition 4 at the scale of the western LBK in Gomart 2014): in the Hesbaye Region at Rosmeer and Fehxe-le-Haut-Clocher, and in Hainaut at Aubechies.

The third way of doing (VPP3, n=17) includes vessels with bases shaped from a circular clay slab, possibly formed through modelling, around which thin, superimposed and only slightly deformed coils are adjoined. The body, neck and rim of the vessels associated with the VPP3 technical tradition show regularly spaced voids, and a subcircular organisation of the inclusions and pores (O or C configuration), suggesting roughing-out of the body, neck and rim by superimposing thin and only slightly deformed coils. This way of doing has also been identified at the earliest known site of Rosmeer, in the Hesbaye Region (named Tradition 5 at the scale of the western LBK in Gomart, 2014).

The fourth way of doing (VPP4, n=7) includes vessels without preserved bases. Their body and neck are characterised by a subcircular orientation of inclusions and pores (O or C configuration) in radial section, indicating shaping with superimposed, thin, and only slightly deformed coils. The rim of these vases, meanwhile, was formed with a stretched coil so as to obtain a wide band of clay, that is then folded up. This way of doing can be found at the Cuiry-lès-Chaudardes site in the Aisne Valley (named Tradition 6 at the scale of the western LBK in Gomart, 2014). As the four ceramic ways of doing identified at Verlaine occur on other LBK sites attributed to different LBK chronological phases and located in different settlement areas, they can be defined as technical traditions transmitted in space and time.

3.2. The BQY/VSG lithic and ceramic subsystems

3.2.1. The BQY/VSG lithic industry from Vaux-et-Borset site

Blade production in the BQY/VSG sector at Vaux-et-Borset indicates the coexistence of four ways of doing (Denis & Burnez-Lanotte, 2020; Denis et al., 2021).

A strong correlation could be demonstrated between the absence of preparation of the striking platforms and the use of a punch for the preparation of overhangs, the main criterion for identifying way of doing no. 1 (MF1; n=173 pieces; fig. 5). Knappers composing this learning network primarily exploited Campanian flint from the Hesbaye Region. The second way of doing is defined by striking platform preparation through the removal of small, centimetric flakes, serving as concavities in which the punch can then be positioned (concave butts or ineffective dihedrals). A stone tool is used in the preparation of the overhangs (MF2; n=118 pieces; fig. 5). This way of doing has been identified on exogenous flint, namely Ghlin and tertiary Bartonian flint. A third way of doing (MF3; n=23 pieces; fig. 5), only found

on blades in Maastrichtian flint, also shows the removal of smaller flakes on the striking platform. Here, however, the intention is the creation of dihedrals for positioning the punch (intentional dihedral).

This technical mode helps to remove overhangs. The tool used to prepare the rare conspicuous overhangs has not been formally identified, due to the rarity of samples. The last way of doing (MF5; n=53 pieces; fig. 5) was applied to some blades in Campanian flint from Hesbaye. However, striking platform treatment is ambiguous. While plain and flat butts are dominant, the proportion of blades with plain concave butts, ineffective dihedrals and intentional dihedrals is decidedly more significant than for the first way of doing (MF1). This suggests a coexistence of different modes, that is, an inferior mastery of the processes of striking platform preparation, or their reinterpretation. Overhangs are prepared with a stone tool. Furthermore, the blades are markedly more regular, which is in keeping with the clearly smaller dimensions of the butts than for MF1. Finally, an examination of the operational codes demonstrates that knappers mastered the knowledge and were capable of implementing specific debitage procedures to produce blades with a regular and trapezoidal section in the manner of knappers using MF2 and MF3. This is not the case for knappers from the first group (MF1).

Thus, the BQY/VSG sector at Vaux-et-Borset shows a diversity of ways of doing, with four identified variations. The first is similar to the one described with relation to the LBK in Hesbaye. It was interpreted as a technical tradition in its own right, and has been labelled *beta tradition* (Denis & Burnez-Lanotte, 2020). The second one (MF2) is characteristic of Hainaut Province and the Paris Basin and, in the current state of research, it is exclusive to those regions (Bostyn, 1994; Bostyn et al., 2019; Denis, 2017). Its roots can be identified in the LBK (Allard, 2005a), so MF2 can also be interpreted as a technical tradition in its own right (*alpha tradition* after Denis & Burnez-Lanotte, 2020). The dihedral butts, specific to MF3, were previously identified in a Grossgartach and Planing-Friedberg/North Rhine context (Denis, 2020; Denis et al., 2019). The ubiquitous characteristics of MF3, stemming from both *alpha* and *beta* traditions, highlight its hybrid nature (Denis & Burnez-Lanotte, 2020).

3.2.2. The BQY/VSG ceramic from Vaux-et-Borset site

In the ceramic assemblage from the BQY/VSG sector of Vaux-et-Borset, 556 vessels were examined, 268 of which could be linked to a manufacturing *chaîne opératoire* (van Doosselaere et al., 2013, 2016). Three ways of doing were identified (fig. 7). Present in almost equal proportions in the pits of the site, these can be considered as contemporaneous.

The first way of doing (n°1, n=86) is characterised by a roughing-out of the vessels' base, body and rim by assembling coils, with alternately internal and external orientation (Z or S configuration), suggesting alternating internal and external compression during assembly. They were then shaped using the beating technique. This way of doing has of yet not been identified as such in an LBK context, but the roughing-out operations (S or Z coils) are similar to those on several vessels from the Rosmeer and Fexhe-le-Haut Clocher sites in Hesbaye, as well as from Aubechies in the Hainaut region (Gomart, 2014). The shaping

(beating technique) resembles the Ennery 'Le Breuil-Projet Alloin' assemblage in the Moselle region, where the use of this technique has been identified on much of the ceramic assemblage, and to a lesser degree, the assemblages of Cuiry-lès-Chaudardes, Rosmeer, Fexhe-le-Haut-Clocher and Metz-Nord (Gomart, 2014).

The second way of doing (n°2, n=57) includes ceramics with bases formed from spiralled coils, and with bodies shaped from externally and obliquely overlapping and compressed coils. The vessels are then shaped using the beating technique. It is possible to establish a link between the roughing-out operations of this second way of doing at Vaux-et-Borset and the technical tradition associated with the 'standard' so-called Limburg ware found in LBK contexts, the forms and technical traits of which differ from typical LBK pottery (see Tradition 7 in Gomart, 2014; Gomart & Burnez-Lanotte 2012). This Limburg tradition is attested at the Rosmeer and Fehxe-le-Haut-Clocher sites in Hesbaye, the Aubechies site in Hainaut, and at Cuiry-lès-Chaudardes in the Aisne Valley. The technique of shaping through beating corresponds to the one from the LBK site at Ennery in the Moselle region.

The third way of doing (n°3, n=28) comprises vases with bases, bodies and necks consisting of superimposed thin and only slightly deformed coils. These vessels are then shaped out using the beating technique. The roughing-out operations are comparable to those of the LBK sites of Rosmeer and Fexhe-le-Clocher in Hesbaye, and Cuiry-lès-Chaudardes in the Aisne Valley.

The three ceramic ways of doing identified in the BQY/VSG sector of Vaux-et-Borset relate to technical practices identified during the LBK in different settlement areas, and can in this respect, be considered as technical traditions, even if the detailed sequences of technical gestures seem to slightly change between the LBK to the post-LBK.

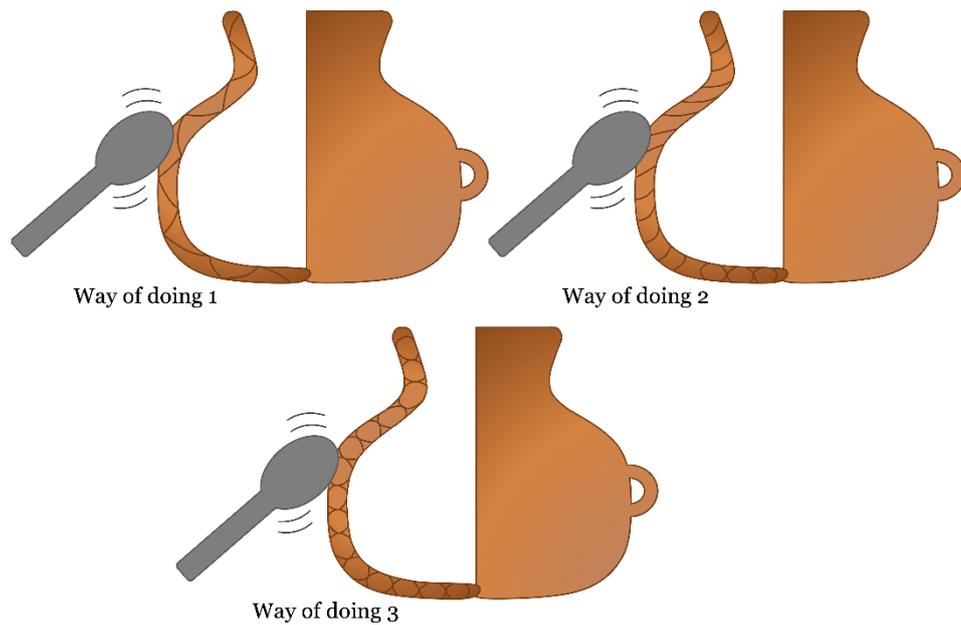


Fig. 7 Schematic representation of the three ceramic ways of doing identified in the BYQ-VSG sector of Vaux-et-Borset

4. Discussion

4.1. Lithic and ceramic production: comparable production structures?

Bringing to light different technical traditions in the lithic and ceramic industries during the transition between the LBK and BQY/VSG in the Hesbaye region reveals similarities, as well as dissimilarities between the two technical subsystems. During the LBK, the lithic industries show marked homogeneity with a strong local technical identity specific to the Hesbaye region and predominant at both Verlaine and Vaux-et-Borset (MF1). Ceramic production is also relatively homogeneous at the scale of the site (VPP1 being largely dominant in the Verlaine corpus), but is characterised by greater diversity at the scale of the whole settlement area (the prevalent way of doing at Verlaine does not predominate the whole Hesbaye region). The BQY/VSG sees an important diversification of technical practices within the two technical subsystems at the scale of the site. Indeed, no less than four lithic technical traditions have been identified at Vaux-et-Borset, two of which are clearly predominant, and three ceramic technical traditions, all of which are present in significant proportions.

In general, the lithic and ceramic subsystems thus seem to follow a broadly similar trend, with a diversification of practical techniques during the BQY/VSG. The fact that lithic and ceramic technical groups do not quite overlap can, however, lead to the supposition that the two subsystems are indicative of two distinct production contexts, with a probable repartition of labour within the LBK and BQY/VSG communities. This observation is important, as it allows for a dynamic reading of the LBK-BQY/VSG transition, where the socio-economic practices of several social groups have to be considered.

4.2. New keys for understanding the transition mechanisms between the LBK and post-LBK in the Hesbaye region

The exploration of the structures of technical traditions during the LBK-BQY/VSG transition reveals a strong similarity in the functioning of the ceramic and lithic subsystems. Three mechanisms seem to coexist during the transition: filiation, migration and syncretism.

4.2.1. Continuity of settlement between the LBK and BQY/VSG

A continuity between the LBK and BQY/VSG was identified for the two technical subsystems. With regard to the lithic industry, the *beta* technical tradition (corresponding to the way of doing no. 1) is virtually exclusive to the LBK and strongly rooted in the Hesbaye territory (Allard, 2005a; Denis & Burnez-Lanotte, 2020). It persists throughout the transition period, as it can be identified in significant proportions at the BQY/VSG site at Vaux-et-Borset. It is also prevalent at the neighbouring site of Darion (Denis, 2017).

With regard to ceramics, it is possible to establish parallels between the roughing-out associated with the technical traditions identified at Vaux-et-Borset, and those implemented at Verlaine: the VPP2 technical tradition at Verlaine thus echoes the roughing-out operations of the vessels' body associated with tradition no. 1 at Vaux-et-Borset. The same is true for technical traditions 1 and 3 of Vaux-et-Borset, with roughing-out operations reflecting the shaping methods of vessels' body for the VPP3 and VPP4 traditions at Verlaine. The three technical traditions identified at Vaux-et-Borset were discovered at two other sites in the Hesbaye region that represent a large part of the LBK sequence of the area, namely at Rosmeer and Fexhe-le-Haut-Clocher.

As the "temporal stability of the forming traditions makes them a privileged variable for assessing producers' social affiliation" (Roux, 2020, p. 20), the diachronic persistence of local lithic and ceramic technical traditions between the LBK and the BQY/VSG testifies to the intergenerational transmission of know-how within the same social group. The existence of this intergenerational transmission allows to identify a "social filiation" between the LBK and the BQY/VSG, here understood as a shared "education, [an] inclusion in the lineage" (Martial, 2012). This social filiation between the LBK and

BQY/VSG in the Hesbaye region attests to the indubitable continuity of population in this settlement area.

4.2.2. A transition marked by exogenous influences originating from other Danubian settlement areas

Alongside the continuity observed in the Hesbaye region, exogenous influences also seem to have profoundly marked the transition between the LBK and BQY/VSG, for both of the examined technical subsystems. Concerning lithic industries, the *alpha* technical tradition (or way of doing no. 2 is the direct result of the migration of a small group from Hainaut to the Hesbaye region, comprising knappers with a very high level of expertise (Denis, 2014, 2017; Denis & Burnez-Lanotte, 2020). The analysis of siliceous raw materials pinpoints the origin and circulation of the flint, and contributes to determine knappers' movements, or lack thereof. Furthermore, the matching macro-features method, employed in the study of the circulation of tertiary Bartonian flint (Denis, 2019a), seems to confirm that this migration took place from the Hainaut to the Hesbaye. The second trend illustrates links with eastern populations associated with the Grossgartach/Planig-Friedberg groups from the Aachen/Cologne area (Denis, 2020; Denis & Burnez-Lanotte 2020; Denis et al., 2021). In the current state of research, however, we do not have an exact understanding of the relations between the two communities.

In the case of ceramics, exogenous influences can also be assumed, particularly with regard to the shaping of the vessels. In the BQY/VSG sector of Vaux-et-Borset, most of the pottery was shaped using the beating technique. This technique is rarely identified in LBK assemblages in the Hesbaye region, Hainaut or the Aisne valley but was identified on a large majority of vessels from the LBK site of Ennery, in the Moselle region in eastern France (Gomart, 2014). It should also be noted that roughing-out operations associated with traditions 1 and 3 at Vaux-et-Borset reflect practices identified in Hesbaye, but they are also found in the Hainaut region at Aubechies, as well as in the Aisne valley at Cuiry-lès-Chaudardes. More data would be required in order to outline the exact zones of influence marked by the identified technical gestures.

Ultimately, the BQY/VSG lithic and ceramic subsystems display remarkably similar dynamics, with possible influences from both the East (Moselle and northern Rhine) and the West (Hainaut and Aisne valley) (fig. 1). The presence in Hesbaye during the BQY/VSG of exogeneous ways of doing suggests that an intensification of population movements within the Danube sphere itself played an important part in the LBK-BQY/VSG transition. The spatio-temporal trajectories of those populations have yet to be grasped.

4.2.3. Technical hybridisations and social syncretism

Finally, forms of syncretism could also be detected within the two technical systems. We are here referring to the definition proposed by F. Le Brun-Ricalens: “hybridisation (syncretisation): from the

Greek *hybris* (illegitimate union), an action resulting from two different elements, and from the Greek *sugkrêtismós* (union of two Cretans), a coherent mixture within a system of at least two exogenous ones (a variant of addition, in the sense that each element coexists while retaining its particularities)” (Le Brun-Ricalens, 2014, p. 684).

With regard to the lithic industries, this syncretic phenomenon can be observed during the BQY/VSG through way of doing no. 5, which incorporates criteria from both ways of doing no. 1 and 2 identified at the same site. Knowing that, as emphasised above, the two groups of knappers (the local one and the one from Hainaut) undoubtedly came together at some point, we proposed that way of doing no. 5 is the result of a hybridisation of the technical practices employed by these two groups (Denis & Burnez-Lanotte, 2020; Denis et al., 2021).

For ceramics, at Vaux-et-Borset, the systematic association of typically LBK roughing-out operations from Hesbaye region (as well as from Hainaut and the Aisne valley) with shaping operations from the Moselle LBK, points to the existence of hybridisation mechanisms of technical practices during the LBK-BQY/VSG transition. This suggests prolonged and intertwined interactions between pottery producers from distinct learning networks. It may be noted that beating is a very "visible" technique when used for shaping and is not difficult to implement: in the context of prolonged interactions between producers, it might be more easily borrowed and adopted than less visible techniques and procedures that are more deeply rooted in motor habits, such as the direction in which the coils are placed, or their degree of elongation.

In addition, the very high prevalence of technical tradition no. 2 at Vaux-et-Borset, typical of the ‘standard’ Limburg ware in LBK context (Gomart, 2014), is intriguing in many ways. The Limburg ware clearly comes from a different learning network from that of producers of typical LBK ware, yet it is evidently linked, in our view, to the LBK sphere (Constantin et al., 2010; Gomart, 2014; Gomart & Burnez-Lanotte, 2012). The fact that, up until now, no site has revealed a ceramic assemblage composed exclusively of Limburg ware in a reliable context, and that these ceramics maintain homogenous stylistic characteristic in the whole western LBK expansion zone tends, in our view, to refute the hypothesis of production by hunter-gatherer groups (Constantin et al., 2010). Limburg ware is nearly always found in contexts associated with the collective sphere, and imitated by producers of typical LBK ceramics. It thus seems to constitute a specific functional category, and to carry strong cultural significance for the LBK communities. The local origin of the clay used to form Limburg pots, as well as the marked uniformity of the technical gestures associated with their production throughout the whole western LBK chronological sequence, across vast territories including Belgium, the Netherlands and north-eastern France (which stand in opposition to the diversity of technical practices associated with typically LBK assemblages) may suggest that Limburg ware was produced and disseminated by itinerant artisans. These artisans would have formed an integral part of LBK communities, although their social role might have differed from those held by the producers of domestic ware (Gomart, 2014).

The use of tradition no. 2 at Vaux-et-Borset could suggest that the learning network behind the production of Limburg ware during the LBK remained active after the transition towards the BQY/VSG. The producers and the productions themselves would nevertheless have lost their specific cultural and social roles. It is indeed highly probable that for the Neolithic communities in question, a cultural transition would be accompanied by profound transformations in the cultural and social meaning attributed to specific categories of artefacts (Raczky et al., 2010). It is thus possible to suppose that producers from the Limburg learning network, having lost their status as itinerant craftsmen and now making pottery for domestic use, could have established themselves locally in BQY/VSG villages. This new local anchoring would entail prolonged interactions with the descendants of the typical LBK style pottery learning networks, giving rise to important technical and stylistic transfers between producer groups. This scenario of interaction would also explain the spread of bone temper among BQY/VSG assemblages (while it was nearly exclusively used on Limburg ware in LBK contexts), but also the fashioning of large-sized vases with everted walls and the use of impressed or incised herringbone decorative patterns which were hitherto characteristic of Limburg ware.

The different processes of technical hybridisation identified among lithic and ceramic productions could not have emerged without close and prolonged interaction between producers from different learning networks (Roux et al., 2017). The presence of these phenomena at Vaux-et-Borset - in the form of way of doing no. 5 with regard to the lithic industry and the use of the beating technique for the production of the whole pottery assemblage - reinforces our postulate that the western and eastern influences identified in the two technical subsystems during BQY/VSG are indeed the result of exogenous populations inputs at the turn of the fifth millennium that integrated the communities already established in the Hesbaye region, leading to social syncretism visible in the technical system. Another mechanism of social syncretism is represented in the massive employment of technical tradition no. 2 in the BQY/VSG sector of Vaux-et-Borset, formerly associated with Limburg ware, and which suggests a local settling of producers hitherto in charge of making the said Limburg ware. This was probably accompanied by the loss of their specific societal role, as well as that of the status of their production.

4.3. Social mechanisms deeply embedded in migration patterns

The identification of exogenous influences and of technical hybridisation in the BQY/VSG of Middle Belgium led us to speak of social syncretism. These social mechanisms are deeply anchored in migration patterns. Mastering knowledge and know-how related to complex productions (such as lithic blades and pottery productions) requires long and sustained training (Pelegrin, 1991, 2007). Furthermore, some of the technical traits involved in the hybridisation processes are invisible on the finished artefacts. These processes must therefore be related to durable contacts, exchanges and dialogues between individuals that can only stem from the integration of exogenous individuals within the local communities. This

phenomenon involves processes of migration i.e. “a permanent shift of residence of a social unit [probably] larger than an individual” (Hofmann, 2016, p. 235).

The question of the mobility of these sedentary agro-pastoralist populations has become more salient with the introduction of bioarchaeological data into prehistoric narratives (e.g., Bickle & Hofmann, 2007; Hofmann, 2016, 2020; Scharl & Gehlen, 2017; Zvelebil et al., 2012). In the early 2000s, the development of strontium isotope analysis revealed some forms of individual mobility among LBK farmers, especially that of women, which were interpreted as a signal of patrilocality (Bentley et al., 2002; Hedges et al., 2013; Price et al., 2001;). Mobility and migration seem to be an intrinsic component of LBK lifestyles even after the earliest phases of colonisation (Hofmann, 2016), but it has also been argued that “migration episodes which took place within the LBK area will be largely indistinguishable at a molecular level” (Hofmann, 2016, p. 236). This is indeed obvious for example with regard to the hypothesis of itinerant knappers during the BQY/VSG (Denis, 2019a) and itinerant Limburg potters, whose travel routes and rhythms cannot be captured by specific isotopic signatures. It is also important to note that bioarchaeological studies are conducted in funerary contexts, which are especially lacking in our study area.

As M. Furholt (2018) points out, communities of practice which can be tracked thanks to technological analyses are ideal for working on mobility and migration patterns. Using this concept, our study has thus underlined that (1) the LBK is characterised by a homogeneity of lithic technical practices, while pottery technical traditions are diverse; (2) the transition to the BQY/VSG is marked by a diversification of technical practices in both subsystems.

Looking at the organisation of both productions, the dissymmetry between lithics and ceramics observed for the LBK can be discussed in the light of the hypothesis developed for the Neolithic of a gender-specific division of activities, in which ceramic production is often considered a feminine task (e.g., Bickle & Hofmann, 2023; Hofmann, 2020, p. 10) and the production of stone tools is often assigned to men (e.g., Augereau, 2019). For the LBK of Middle Belgium, lithic homogeneity *versus* ceramic diversity fully fits the patrilocality models based on aDNA and isotopes analysis, with a higher mobility signal for women compared to men. However, the transition to the BQY/VSG, which is characterised by a general diversification of technical practices, raises new questions. From the lithic point of view, we observe an intensification of producers’ mobility. Two hypotheses can be discussed. First, the transition between the LBK and the BQY/VSG could be linked to an evolution of kinship systems. This could echo the social network analysis of E. Claßen (2009), which suggests a destabilisation of kinship networks at the end of the LBK in the Cologne/Aachen area. Secondly, we can assume a reorganisation of the techno-economic activities among the post-LBK communities. In the lithic technical subsystem, this is perceptible through the massive development of simple productions during the BQY/VSG, particularly in the Hesbaye region (e.g., Caspar & Burnez-Lanotte, 2008; Denis, 2017). These productions, manufactured on a domestic scale, indicate the appearance of a new group of producers (Denis, 2017) that is independent from the group of blade producers who tends to adopt diverse forms

of specialised organisation (Bostyn et al., 2019; Denis, 2019b). The local settling of Limburg ware producers during the BQY/VSG, probably accompanied by a loss of their specific social role and of the status of their production, is probably part of the same type of socio-economic upheaval.

Conclusion

In the framework of an apparent “rupture” pattern between the LBK and the Blicquy/Villeneuve-Saint-Germain, in the Hesbaye region, our premise was aimed at testing the validity of the three models of historical transition proposed to explain the shift from the LBK to the post-LBK:

- (i) an endogenous process linked to profound socio-cultural mutations within LBK populations;
- (ii) a syncretic process, relating to the integration of Neolithic populations from contemporaneous cultural entities;
- (iii) a syncretic process, relating to the final stage of integration of hunter-gatherer populations.

Our results reveal several overlapping mechanisms were at work in the Hesbaye region during the transition between the LBK and BQY/VSG. In fact, the ceramic and lithic subsystems attest to a combination of filiation, migration, and social syncretism. The technical continuity observed between the LBK and BQY/VSG in the ceramics and lithic industries, which attests to continuity in the peopling of the Hesbaye region, is accompanied by migrations and phenomena of syncretism between groups from different geographical origins, albeit with similar cultural affiliation. The interactions that could be identified in the lithic subsystem seem indeed to be indicative of exchanges between communities from different regions (the Hainaut region or the Paris Basin). In the same vein, the south-eastern influx into the ceramic subsystem stems from the Danubian cultural sphere. These interactions between communities seem to be linked to an intensification of population movements within the Danubian cultural sphere during the transition between the LBK and BQY/VSG. In view of the current state of research, however, neither the lithic nor ceramic subsystem from the Hesbaye region reveals indications of influx from contemporaneous non-Danubian cultural entities (e.g., Cardial, epi-Cardial), nor of the integration of hunter-gatherer populations into BQY/VSG communities.

It is important to underline that profound socio-economic mutations are also perceptible between LBK and BQY/VSG through the massive emergence of lithic simple productions (e.g. flakes), as well as the loss of specific cultural and social roles for the Limburg ware.

This combination of complex phenomena seems to mainly reflect processes specific to the Danubian sphere, although their exact rhythms have yet to be understood. Data retrieved from lithic and ceramic industries point to population movements, but these do not appear to be synchronous. In the present state of the data, the supposed interactions between ceramic communities of practice are identified during the

LBK and seem to only give rise to technical hybridisations during the BQY/VSG. By contrast, the LBK lithic industries are characterised by strong technical homogeneity, with no evidence of transfers between communities of practice. It is only from the BQY/VSG that the lithic subsystem provides evidence of interactions and manifests technical transformations and hybridisations. As shown above, we cannot exclude the possibility that this assessment may only be the reflection of the current state of research. Technological analyses relating to ceramic apprenticeships have so far concentrated on the LBK of the Paris Basin, Belgium and Eastern France, whereas for lithic industries, it is rather the post-LBK assemblages from Belgium and the Rhineland that have been the main focus. Yet this observation may also reflect differing social dynamics depending on the technical subsystem, linked to a gendered distribution of technical labour (e.g., Bickle, 2020; Masclans Latorre et al., 2020; Masclans et al., 2021). It is thus tempting to assume that the intensity of influxes (without visible hybridisation) observed in the ceramic subsystem during the LBK could be the reflection of a strong mobility of women, for instance in the case of matrimonial movements (as suggested by a number of bioarchaeological studies: e.g., Bentley et al., 2002; Price et al., 2001) - women settling where they marry with their own ceramic technical traditions (Gomart et al., 2015, 2017). In parallel, the more local anchoring of lithic technical traditions during the LBK could reflect this patrilocal functioning. The intensification of exchanges and population movements during the BQY/VSG, stemming from changes in social and economic paradigms, would reshape LBK social core structure and give rise to new types of interactions between individuals at the level of the whole society.

The detailed reconstruction of lithic and ceramic technical know-how during the transition between the LBK and BQY/VSG in the Hesbaye region thus reveals groups of producers whose spatial trajectories and socio-economic behaviours seem to change profoundly at the turn of the sixth and fifth millennia BC. This study shows the potential of integrated technological approaches for enhancing our understanding of the first farmers' mobility patterns and for building, beyond central Belgium, robust transition scenarios taking into account in a systemic perspective the cultural, social and economic dynamics that led to the fragmentation and disintegration of the LBK system at the European scale (Denis et al. forthcoming; Marton et al., 2020).

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